

CLAIMS

1. A method for manufacturing grain-oriented silicon steel sheet with mirror-like surface having high magnetic flux density, comprising the steps of:

5 preparing hot-rolled steel sheet by hot-rolling silicon steel slab comprising Si of 0.8 mass% to 4.8 mass%, C of 0.003 mass% to 0.1 mass%, acid-soluble Al of 0.012 mass% to 0.05 mass%, N of not more than 0.01 mass%, with the remainder substantially comprising Fe and
10 unavoidable impurities,

reducing the hot-rolled sheet, as rolled or after annealing, to a final sheet thickness by applying one or two or more cold rollings, with intermediate annealing interposed,

15 forming an oxidized layer consisting mainly of silica on the surface of the cold-rolled steel sheet by implementing decarburized-annealing in an atmosphere gas of such degree of oxidation as to not form Fe-based oxides and,

20 providing a mirror-like surface by finish-annealing the steel sheet applied by an annealing separator consisting mainly of alumina,

the method for manufacturing grain-oriented silicon steel sheet with mirror-like surface being
25 characterized by,

stabilizing secondary recrystallization by controlling the amount of moisture carried in the annealing separator consisting mainly of alumina after application and drying thereof, and the partial water
30 vapor pressure during finish-annealing.

2. A method for manufacturing grain-oriented silicon steel sheet with mirror-like surface having good iron loss properties, comprising the steps of:

35 preparing hot-rolled steel sheet by hot-rolling silicon steel slab comprising Si of 0.8 mass% to 4.8 mass%, C of 0.003 mass% to 0.1 mass%, acid-soluble Al of 0.012 mass% to 0.05 mass%, N of not more than 0.01

mass%, with the remainder substantially comprising Fe and unavoidable impurities after heating the slab at a temperature not higher than 1280°C,

5 reducing the hot-rolled sheet, as rolled
or after annealing, to a final sheet thickness by
applying one or two or more cold rollings, with
intermediate annealing interposed,

 forming an oxidized layer consisting
mainly of silica on the surface of the cold-rolled steel
10 sheet by implementing decarburized-annealing in an
atmosphere gas of such degree of oxidation as to not form
Fe-based oxides,

 applying a nitriding treatment and
 providing a mirror-like surface by finish-
15 annealing the steel sheet applied by an annealing
separator consisting mainly of alumina,

 the method for manufacturing grain-oriented
silicon steel sheet with mirror-like surface being
characterized by,
20 controlling the amount of moisture carried
in the annealing separator consisting mainly of alumina
after application and drying of an aqueous slurry to not
more than 1.5% and,

 injecting an atmosphere gas having a
25 degree of oxidation ($\text{PH}_2\text{O}/\text{PH}_2$) of not lower than 0.0001
and not higher than 0.2 during finish-annealing.

3. A method for manufacturing grain-oriented
silicon steel sheet with mirror-like surface having good
iron loss properties, comprising the steps of:

30 preparing hot-rolled steel sheet by hot-
rolling silicon steel slab comprising Si of 0.8 mass% to
4.8 mass%, C of 0.003 mass% to 0.1 mass%, acid-soluble Al
of 0.012 mass% to 0.05 mass%, N of not more than 0.01
mass%, Mn of 0.03 mass% to 0.15 mass%, S of 0.01 mass% to
35 0.05 mass%, with the remainder substantially comprising
Fe and unavoidable impurities after heating the slab at a
temperature not lower than 1320°C,

reducing the hot-rolled sheet, as rolled or after annealing, to a final sheet thickness by applying one or two or more cold rollings, with intermediate annealing interposed,

5 forming an oxidized layer consisting mainly of silica on the surface of the cold-rolled steel sheet by implementing decarburized-annealing in an atmosphere gas of such degree of oxidation as to not form Fe-based oxides, and

10 providing a mirror-like surface by finish-annealing the steel sheet applied by an annealing separator consisting mainly of alumina,

the method for manufacturing grain-oriented silicon steel sheet with mirror-like surface being
15 characterized by,

controlling the amount of moisture carried in the annealing separator consisting mainly of alumina after application and drying of an aqueous slurry to not more than 1.5% and

20 injecting an atmosphere gas having a degree of oxidation ($\text{PH}_2\text{O}/\text{PH}_2$) of not lower than 0.0001 and not higher than 0.2 during finish-annealing.

4. The method for manufacturing grain-oriented silicon steel sheet with mirror-like surface having good
25 iron loss properties according to claim 2 or 3, characterized by,

injecting an atmosphere gas having a degree of oxidation ($\text{PH}_2\text{O}/\text{PH}_2$) of not lower than 0.0001 and not higher than 0.2 into a temperature zone of 600°C
30 to 1100°C during said finish-annealing.

5. The method for manufacturing grain-oriented silicon steel sheet with mirror-like surface having good iron loss properties according to claim 2, 3 or 4, characterized by,

35 adding Sn or Sb of 0.03 mass% to 0.15 mass% to said steel.

6. A method for manufacturing grain-oriented

silicon steel sheet with mirror-like surface having good iron loss properties comprising the steps of:

5 preparing hot-rolled steel sheet by hot-rolling silicon steel slab comprising Si of 0.8 mass% to 4.8 mass%, C of 0.003 mass% to 0.1 mass%, acid-soluble Al of 0.012 mass% to 0.05 mass%, N of not more than 0.01 mass%, with the remainder substantially comprising Fe and unavoidable impurities after heating the slab at a temperature not higher than 1280°C,

10 reducing the hot-rolled sheet, as rolled or after annealing, to a final sheet thickness by applying one or two or more cold rollings, with intermediate annealing interposed,

15 forming an oxidized layer consisting mainly of silica on the surface of the cold-rolled steel sheet by implementing decarburized-annealing in an atmosphere gas of such degree of oxidation as to not form Fe-based oxides,

20 applying a nitriding treatment and providing a mirror-like surface by finish-annealing the steel sheet applied by an annealing separator consisting mainly of alumina,

25 the method for manufacturing grain-oriented silicon steel sheet with mirror-like surface being characterized by,

 controlling the amount of moisture carried in the annealing separator consisting mainly of alumina after application and drying of an aqueous slurry thereof to not more than 1.5% and

30 injecting an inert gas having a dew point of not higher than 0°C as the atmosphere gas during finish-annealing.

7. A method for manufacturing grain-oriented silicon steel sheet with mirror-like surface having good iron loss properties comprising the steps of:

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 preparing hot-rolled steel sheet by hot-rolling silicon steel slab comprising Si of 0.8 mass% to

4.8 mass%, C of 0.003 mass% to 0.1 mass%, acid-soluble Al of 0.012 mass% to 0.05 mass%, N of not more than 0.01 mass%, Mn of 0.03 mass% to 0.15 mass%, S of 0.01 mass% to 0.05 mass%, with the remainder substantially comprising
5 Fe and unavoidable impurities after heating the slab at a temperature not lower than 1320°C,

reducing the hot-rolled sheet, as rolled or after annealing, to a final sheet thickness by applying one or two or more cold rollings, with
10 intermediate annealing interposed,

forming an oxidized layer consisting mainly of silica on the surface of the cold-rolled steel sheet by implementing decarburized-annealing in an atmosphere gas of such degree of oxidation as to not form
15 Fe-based oxides, and

providing a mirror-like surface by finish-annealing the steel sheet applied by an annealing separator consisting mainly of alumina,

the method for manufacturing grain-oriented
20 silicon steel sheet with mirror-like surface being characterized by,

controlling the amount of moisture carried in the annealing separator consisting mainly of alumina after application and drying of an aqueous slurry thereof
25 to not more than 1.5% and

injecting an inert gas having a dew point of not higher than 0°C as the atmosphere gas during finish-annealing.

8. The method for manufacturing grain-oriented
30 silicon steel sheet with mirror-like surface having good iron loss properties according to claim 6 or 7, characterized by,

injecting inert gas having a dew point of not higher than 0°C as the atmosphere gas into a
35 temperature zone of 600°C to 1100°C during said finish-annealing.

9. The method for manufacturing grain-oriented

silicon steel sheet with mirror-like surface having good iron loss properties according to claim 6, 7 or 8, characterized by,

5 adding Sn or Sb of 0.03 mass% to 0.15 mass% to said steel.